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Supply Chain Analysis, Challenges and Opportunities in the Aquaculture Industry (Case Study: Karimun Jawa, Central Java)

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Abstract

Aquaculture of Grouper Fish using floating net cages in Karimun Jawa, Central Java, is a growing industry that provides significant benefits to coastal communities. This study aims to identify the supply chain, analyse added value, determine the industry status, evaluate the distribution network, and address the challenges and opportunities within the aquaculture industry. Grouper Fish supply chain management is categorized into five main elements: fish seed suppliers, fish farming (hatchery process, enlargement process, and harvesting process), marketing channels (live and dead fish collectors), processing (domestic markets and fish processing companies), and consumers (restaurants, local consumption, and exporters). Moreover, the distribution network consists of four main models: direct sales, wholesalers, fish processors, and retailers. Identified challenges and opportunities for improving the coastal economy of Karimun Jawa include regulatory aspects of water zoning, Grouper Fish cultivation, resilience, regulations, exports, and Grouper Fish by-products. This research employed descriptive quantitative and qualitative methods using the Food Supply Chain Network (FSCN) approach. Supply chain performance, measured using the FSCN framework, showed farmer shares for fresh and dead fish at 88% and 60%, respectively, indicating that the supply chain performance and marketing efforts are efficient.

Keywords: Supply Chain, Aquaculture, Grouper Fish, Asia, Food Supply Chain Networks

Introduction

Indonesia is an archipelago consisting of more than 17,000 islands with approximately 81,000 kilometers of coastline. The country has a significant potential for aquaculture development, covering an area of 26,606,000 hectares. The offshore area of Karimun Jawa, managed by the Central Java Provincial Marine and Fisheries Service, serves as one of the initiatives to increase fisheries production, particularly Grouper Fish (Epinephelinae), which is a leading fisheries commodity. The fish sector presents particularly challenging supply networks due to the high perishability of seafood, the presence of various independent agents within the supply chains, and uncertainties surrounding sourcing [1]. Therefore, supply chain and value chain analysis are essential for identifying the challenges and opportunities within this sector, as they provide a foundation for developing a resilient and efficient supply network that benefits both businesses and the broader industry [2]. In this context, the aquaculture industry encompassing the cultivation of fish and aquatic organisms in both freshwater and mariculture environments plays a key role [3]. While studies on the challenges and opportunities within the aquaculture industry have been conducted in various regions, such as Singapore and Columbia further analysis is needed to understand the unique dynamics of the aquaculture sector in different contexts [2, 4]. Despite the scarcity of comprehensive supply and value chain analyses for Grouper Fish in Indonesia, similar studies have been conducted in other aquaculture sectors, such as shrimp farming and oysters [5, 6]. However, research on Grouper Fish faces unique challenges, particularly environmen-

tal issues, including water pollution, water quality degradation, disease outbreaks, and the spread of diseases among aquatic organisms like fish and shrimp populations, as well as concerns regarding the sustainability of fish feed sources.

The problems facing this research are several environmental issues including water pollution, water quality degradation, disease and disease spread in aquatic organisms such as fish and shrimp populations, use of fish feed sources. Climate change can affect water temperature, rainfall patterns and water acidity levels which can affect the health and growth of aquatic organisms. High operational and production costs for stakeholders are water and energy management, water quality management, infrastructure costs, feed selection and feeding, complex supply chains involving various stages from breeding, rearing, processing to distribution of the final product [7]. The novelty of this research on aquaculture supply chains is that research is still rare at Indonesia.

Methodology

The research method used was a combination of descriptive quantitative and qualitative approaches, employing the Food Supply Chain Network (FSCN) approach [8]. Qualitative descriptive analysis was utilized to examine the aquaculture supply chain following the stages of the FSCN framework. Meanwhile, quantitative analysis focused on evaluating the added value of each supply chain member. The Food Supply Chain Networks consists of four stages: supply chain structure, supply chain business processes, network and chain management and supply chain resources [9].

1. The initial stage of the research, Study Area. This stage involved conducting observations of the study area in the offshore floating net cage aquaculture (KJA) in Karimun Jawa. All survey respondents were drawn from communities and industries involved in the aquaculture supply chain.
2. The second stage, Farm Survey. Survey respondents represented nine elements of the supply chain, including pre-harvest (nurseries and farmers) and post-harvest (wholesalers, cooperatives, processors, retailers, domestic consumers, food services, and exporters). Respondents were interviewed directly, selected based on data accuracy, accessibility, and representation of the industry. Participation was voluntary and confidential.
3. The third stage is Survey Questions. The survey questions were developed based on similar studies. Two types of surveys were created: one for pre-harvest (nurseries and farmers) and another for post-harvest (elements beyond the farming sphere). The surveys consisted of 28 questions, with 20 being closed-ended and eight open-ended. All questions captured respondents perceptions and experiences related to their businesses or operations. Interviews were conducted by one or two researchers in person, lasting approximately 15 minutes.
4. The fourth stage is Data Validation. This stage involved a comprehensive data validation process to ensure accuracy and reliability. Two levels of validation were employed: raw data and supply chain data. For raw data, researchers cross-checked recorded responses for consistency. Supply chain and value chain data were validated by an independent expert from the Karimun Jawa National Park Center, which oversees aquaculture development in Indonesia.
5. The fifth stage is Data Analysis. A semi-quantitative analysis was conducted using descriptive statistics within the FSCN framework.

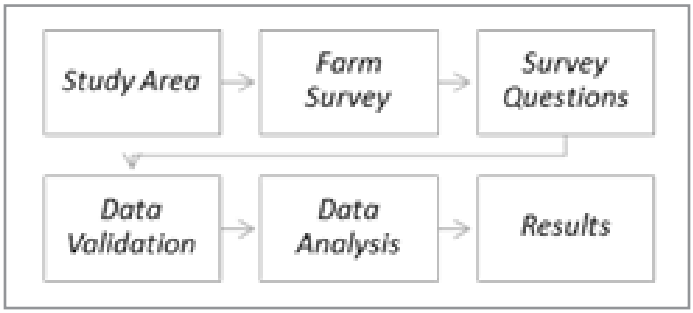

Figure 1: Research Flowchart

Study Area

The Karimunjawa Islands are located in the Java Sea, approximately 80 kilometers north of Central Java, Indonesia. The islands boast diverse marine and terrestrial ecosystems, including coral reefs, seagrass beds, mangrove forests, and a variety of unique flora and fauna. The Seawater Fish Hatchery and Farm (BPIAL), covering an area of approximately 0.23 hectares in Karimunjawa Village, Karimunjawa Sub-district, Jepara District, conducts several activities. These include rearing Grouper Fish fry from 6 cm to 10 cm over a period of about one month, enlarging Grouper Fish in Floating Net Cages to a consumption size of 500 grams over a period of 10 to 18 months, and processing activities such as harvesting, packaging, and marketing Grouper Fish.

Table 1: Survey Responden

Suply Chain Element	Respondent (n)
Pre-harvest elements	
Supplier	8

Farmers	10
Post-harvest elements	
Dead Fish Traders	2
Fresh Fish Traders	2
Exporters	2
Local Consumption	3
Traditional and Modern Markets	2
Restaurant	2
Retailers	5

Based on Table 1, a total of 36 survey respondents participated, all of whom were selected exclusively from the island of Karimun Jawa. On average, these respondents (including both pre-harvest and post-harvest participants) have been trading Grouper Fish for approximately 10 to 20 years. The supply chain involves nine key elements: two respondents represent the hatchery stage, two represent live Grouper Fish collectors, and the rest represent dead fish collectors, restaurants, exporters, retailers, and domestic consumers.

Two respondents completed the pre-harvest survey, while seven respondents participated in the post-harvest survey. All respondents who completed the pre-harvest survey used the "Floating Net Cage" system, the most common type of production system, where Grouper Fish are kept in nets floating in the sea. In the post-harvest survey, the export shipment volume of live Grouper Fish was conducted twice a year, with each shipment ranging from 100 to 200 kg. The average weight of post-harvest Grouper Fish is approximately 500 grams per fish.

For the domestic market in Indonesia, the shipment volume of live Grouper Fish is about 100 kg per shipment. In contrast, the shipment volume of dead Grouper Fish ranges between 25 and 50 kg per month.

Survey Questions

The survey questions were designed based on similar studies and through discussions between the researcher and the research assistant. Two types of surveys were administered: a pre-harvest sector survey focusing on hatcheries and a post-harvest sector survey addressing elements beyond the farm gate. The differences between the two surveys were minimal; the pre-harvest survey included two additional questions related to farming practices and the supply of fry and feed, while the post-harvest survey included two additional questions regarding the purchase and sale of live and dead Grouper Fish within the supply chain.

Both types of surveys consisted of 28 questions, including 20 closed-ended questions (checkbox options) and 8 open-ended questions. All questions were designed to gather information about respondents' perceptions and experiences regarding their business or operations. The surveys were conducted in person by one or two researchers, with each session lasting approximately 15 minutes.

The purpose of the survey was to obtain accurate and comprehensive data on various aspects of the Grouper Fish supply chain in Karimun Jawa, spanning pre-harvest to post-harvest stages, to support the analysis and development of more effective strategies in supply chain management.

Data Validation

There were two levels of data validation: raw data and supply chain data. The supply chain data was evaluated by an independent expert from the Balai Perbenihan dan Ikan Laut (BPIAL), which is responsible for managing aquaculture development in Karimun Jawa, Jepara. Data on the supply chain and its value, collected through the survey, was compared with existing knowledge at BPIAL. Validation of the raw data involved an independent researcher assessing the accuracy and reliability of the survey results and respondent interviews.

Data Analysis

Supply Chain Management, specifically, is the process of properly managing the flow of resources and finished items from merchants to customers, with manufacturing facilities and warehouses serving as potential intermediate steps [10].

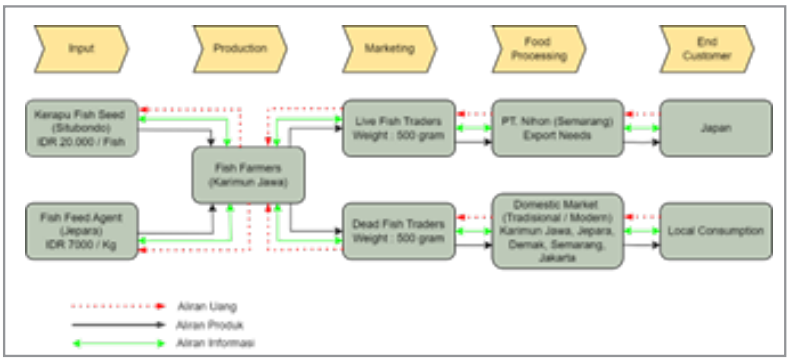

Figure 2: Grouper Fish Supply Chain

Product Flow (Grouper Fish Marketing Channel)

The product flow in the Grouper Fish supply chain in Karimun Jawa consists of several main stages, starting from the farming process to distribution to the end consumer. Overall, the aquaculture supply chain involves a series of processes and networks that maintain product quality at every stage of production until it reaches the consumer [11]. In this context, the interconnections within Indonesia's aquaculture supply chain include steps from upstream to downstream, incorporating environmentally friendly aquaculture practices and water quality management technologies to ensure industry sustainability Consequently, Grouper Fish products can be divided into two main types based on distribution conditions: Fresh Fish and dead fish, both catering to domestic and export markets while maintaining quality and sustainability [12].

Fresh Fish

- **Destination Market:** Shipping live Grouper Fish to Japan through PT Nihon in Semarang is conducted using a closed transportation method that preserves the quality and freshness of the fish. This process utilizes plastic bags containing a calculated amount of oxygen to meet the fish's needs during long-distance transportation [13]. In addition to export needs, live Grouper Fish is also distributed to local fish collectors, who then supply the fish to partners or trusted parties for further cultivation or marketing based on their requirements. The market price for duck Grouper Fish is approximately 400,000 IDR per kilogram.
- **Distribution Procedures:** The distribution of Fresh Fish requires special procedures, including packaging and transportation systems designed to keep the fish alive until it reaches the destination market. Once harvested, the fish is transported to Jepara using an express boat equipped with oxygen and running water in a penguin toren, costing 550,000 IDR per quintal. From Jepara, the fish is transported to Semarang via pickup truck at a cost of 2,000,000 IDR which also covers the collection of water and oxygen. Upon arrival in Semarang, the fish is delivered to PT Nihon for further processing. At PT Nihon, the fish is killed and stored in freezers in preparation for export to Japan or distribution to Jakarta for restaurant supply.

Dead Fish

- **Destination Market:** Dead Grouper Fish is distributed to domestic markets, including traditional and modern markets in various cities such as Karimun Jawa, Jepara, Semarang, Jakarta, and Demak. The price of dead Grouper Fish is approximately 100,000 IDR per kilogram.
- **Distribution Procedure:** This market typically receives products at more affordable prices and uses cooling media such as wet ice and ice packs to preserve the freshness of fish during transportation [14]. Fishermen initiate this process by using 20 liters of diesel per trip, allowing them to catch approximately 50–70 kilograms of fish per day. Afterward, collectors in Karimun store the fish using ice cubes, with a ratio of 5 kilograms of fish requiring 1 kilogram of ice cubes. When the boat schedule permits, the fish is sent to Jepara. The cost of porters is 20,000 IDR per quintal, typically employing an average of four workers, while the boat transportation cost is also 20,000 IDR per quintal. Upon arrival in Jepara, the fish is transferred to a warehouse at a cost of 20,000 IDR per quintal. From Jepara, the fish is sold to local markets or sent to Semarang and distributed at the fish market using pickup truck transportation.

Financial Flow

The financial flow in the Grouper Fish supply chain reflects the distribution of value in rupiah as it moves from downstream to upstream actors. This ensures that farmers, collectors, and retailers gain added value from their activities [11]. The selling price of Grouper Fish varies based on the type and condition of the fish, as well as agreements between supply chain actors.

For fresh Grouper Fish exported through PT Nihon, payments are made on a cashless basis via bank transfer, following the previously agreed road note. This system ensures that PT Nihon receives payment based on the quantity and quality of fish exported, adhering to the agreed schedule with international partners.

In contrast, domestic markets tend to use cash transactions in traditional markets, accommodating local consumer preferences that prioritize transaction flexibility. Payments are made directly at the time of purchase, facilitating distribution and supporting trader operations [15]. Conversely, modern markets such as supermarkets and restaurants have adopted cashless payment systems, utilizing bank transfers or digital payment methods. This system relies on receipts as proof of billing, which must be paid by the buyer to the cultivator or collector, ensuring transparency in financial records [16]. These varied transaction methods make the supply chain more efficient and tailored to each market segment.

Information Flow

The flow of information is crucial for ensuring the smooth movement of products and finances within the Grouper Fish supply chain in Karimun Jawa. Timely and accurate information enables each actor in the supply chain, from cultivators to end consumers, to coordinate effectively and meet market demands [11]. The information flow between supply chain members includes details about the price, quality, and quantity of fish and operates reciprocally among market actors to support seamless operations.

Below is an overview of the information distribution flow within the Grouper Fish supply chain:

- **Traditional Markets and Local Collectors:** Information about the price, quality, and quantity of Grouper Fish is typically conveyed by collectors to farmers through direct communication. This communication is tailored to the needs of traditional markets, where demand is often daily. Prices in traditional markets can fluctuate based on supply and demand dynamics, as observed in research on tilapia supply chains, which highlighted the importance of market information and coordination between collectors and farmers to maintain smooth distribution of fish products [16].
- **Export Market Through PT Nihon:** In modern markets, such as supermarkets and restaurants, and export markets primarily targeting Japan, information is usually communicated through written agreements. PT Nihon, which handles Fresh Fish exports, contacts farmers by phone to discuss

product specifications, quantities, and delivery schedules. Effective coordination among PT Nihon, collectors, and farmers is essential to ensure all parties are well-informed about market needs and requirements.

Demand patterns differ between restaurants and supermarkets. Restaurants often require a daily supply of fresh fish, while hotels and supermarkets place weekly or monthly orders based on pre-arranged agreements. These agreements cover details such as negotiated prices, delivery times, and quantities of fish to be supplied.

- **Production Input Provider:** Information regarding the need for fish seed and feed is passed from farmers to seed providers in Situbondo and feed agents in Jepara. Specific requests about the required quantity and quality of seed and feed are conveyed through agreed communication channels, such as telephone.

With a well-organized and timely flow of information, every actor in the Grouper Fish supply chain can ensure that products meet market and consumer needs. Effective information management supports the smooth operation and long-term sustainability of the supply chain as a whole.

Results and Discussion

Supply Chain Structure

The Grouper Fish supply chain structure in Karimun Jawa comprises a series of interconnected actors and processes, spanning from the provision of production inputs to the distribution of products in both domestic and international markets. The interactions among these actors—including seed suppliers, collectors, and exporters—form a complex yet efficient network that ensures Grouper Fish from Karimun Jawa reaches consumers while adhering to high-quality standards .

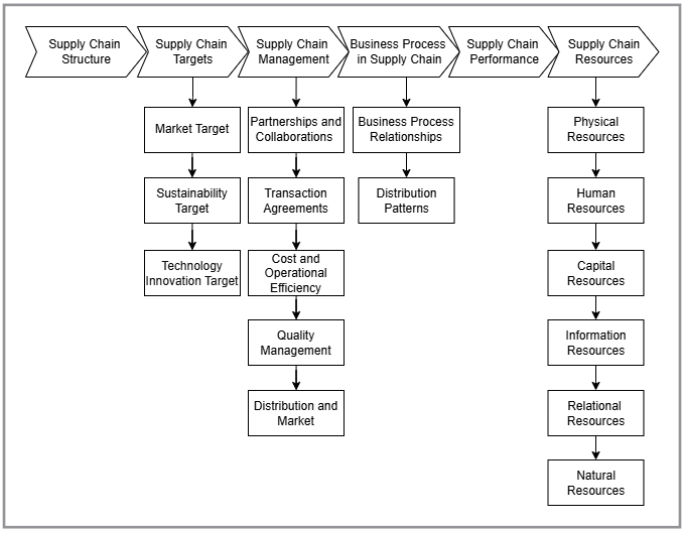

Figure 3: Structure Supply Chain

Supply Chain Goals

Target Market

The target market in the Grouper Fish supply chain emphasizes addressing the demands of both domestic and international markets while ensuring the maintenance of product quality. Domestically, the primary objective is to fulfill the demand for fresh fish in various traditional and modern markets, restaurants, and hotels across Indonesia, particularly in major cities such as Jakarta, Semarang, and Jepara. Achieving broader market penetration within the country is anticipated to provide income stability for farmers and collectors.

Internationally, Japan serves as the primary export destination, particularly for live Grouper Fish that must adhere to stringent quality standards. Furthermore, expanding into new export markets forms a critical component of the strategy to enhance market reach, minimize reliance on a single country, and foster sustainable long-term growth.

Sustainability Goal

Sustainability and emerging technology are the main issues in any supply chain management (SCM) sector, and in the case of the Grouper Fish supply chain in Karimun Jawa, these issues are especially relevant because the sustainability goals prioritize achieving a balance among environmental, economic, and social aspects [17].

Environmental Sustainability

The primary goal is to preserve the quality of seawater surrounding the floating net cages through stringent monitoring, thereby preventing pollution that may harm the ecosystem. Effective waste management practices, including the handling of leftover feed and fish waste, are prioritized to minimize environmental impact. Efficient resource utilization is also emphasized, focusing on optimizing the use of feed, water, and energy to reduce waste and enhance operational efficiency [12].

Economic Sustainability

From an economic perspective, the objective is to ensure operational continuity by maintaining profitability through efficient cost management and providing long-term financial support to farmers and collectors [16].

Social Sustainability

Social welfare forms a key element of the sustainability agenda, requiring the provision of fair wages, comprehensive training, and safe working conditions for workers and farmers. Active involvement of local communities in aquaculture activities is also expected to generate sustainable economic benefits for the communities surrounding Karimun Jawa, ensuring that the industry's growth aligns with enhanced social and environmental well-being.

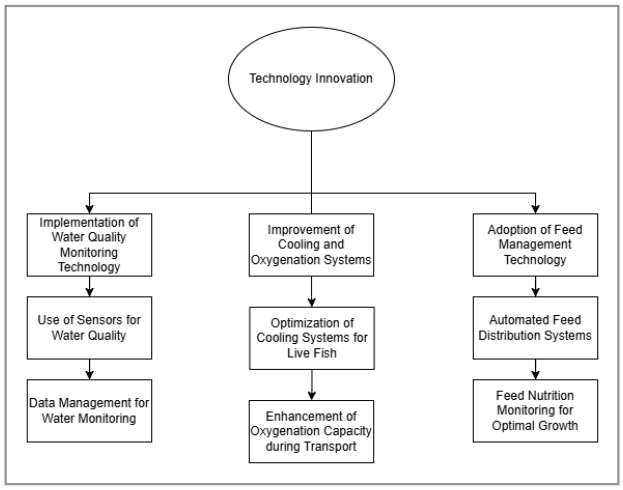

Figure 4: Technology Innovation Goals

Technology Innovation Goals

Application of Water Quality Monitoring Technology: The application of Internet of Things (IoT) sensors in water quality monitoring enables the real-time tracking of essential parameters such as temperature, pH, and oxygen levels, all of which are critical for optimizing fish growth. These sensors support farmers by providing timely alerts via a mobile application, allowing for immediate responses to potential risks or fluctuations in water quality [16].

Data Management for Water Monitoring: Data from water quality sensors is systematically collected and analyzed at regular intervals. This facilitates rapid intervention when water quality deteriorates, ensuring the health of the aquatic ecosystem. The integrated system presents real-time data on the mobile application, enhancing the ease with which farmers can monitor and maintain optimal conditions for fish health [18].

Cooling and Oxygenation System Upgrade

Optimization of Refrigeration System for Fresh Fish: The Refrigerated Sea Water (RSW) system maintains a stable storage temperature of 5°C during transportation, preserving the quality of fish and reducing stress during long-distance transit to export markets. This technological innovation plays a crucial role in maintaining fish quality throughout the shipping process [18].

Enhanced Oxygenation Capacity in Shipping: The optimized oxygenation system ensures that fish receive adequate oxygen during transport, which is critical for minimizing mortality rates. The system's oxygen circulation and supply can be automatically regulated via the mobile application, providing efficient control throughout the shipping process [18].

Adoption of Feed Management Technology

Automated System for Feed Distribution: The automation of feed distribution ensures that fish are fed at optimal intervals and in appropriate quantities, which improves feed efficiency and supports healthier fish growth. This system is integrated with water quality monitoring, allowing for the adjustment of feed quantities based on changing environmental conditions [19].

Feed Nutrient Monitoring for Optimal Growth: Monitoring the nutrient content of fish feed ensures that fish receive the necessary nutrition to support healthy development. This system also prevents overfeeding, which can negatively impact water quality and the overall health of the fish [20].

Supply Chain Business Process

In the Grouper Fish supply chain in Karimun Jawa, the relationships between key stakeholders—farmers, collectors, distributors, retailers, and consumers—are essential for ensuring an efficient and responsive system. Farmers produce Grouper Fish, which are subsequently collected by middlemen or collectors. The relationship between farmers and collectors is typically demand-driven (pull), where the volume of supply is determined by market demand. However, during periods of heightened demand, such as during export seasons or holidays, the relationship shifts to a push model, where farmers increase production to meet this demand.

After collection, the fish is distributed by distributors to both local and export markets. The interaction between distributors and retailers generally follows a pull model, with retailers ordering products according to market demand. Nonetheless, during peak demand periods, distributors may adopt a push strategy to ensure adequate stock levels. Finally, retailers sell the fish to consumers. Consumers ultimately trigger the pull process, driving demand through the supply chain, although retailers may also push products through promotional activities or special requirements. This dynamic interplay between pull and push strategies ensures a continuous and adaptive flow of products, effectively responding to the fluctuations in market demand.

Consumers trigger the pull process, drawing products through the supply chain. However, retailers can also adopt a push strategy during promotions or special circumstances. This dynamic interaction ensures a smooth flow of products and allows the supply chain to adapt to fluctuations in market demand.

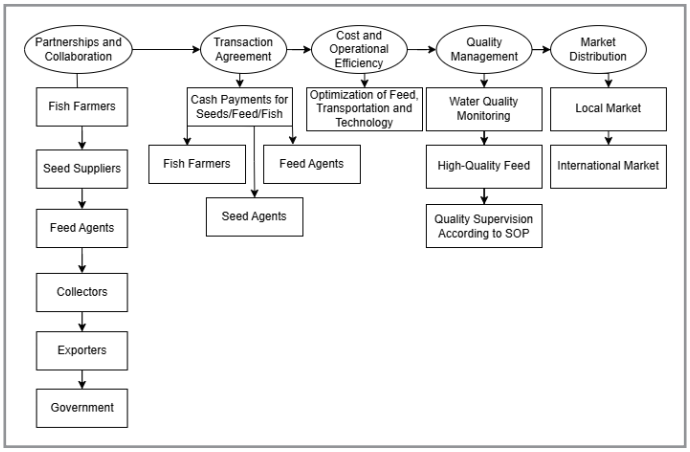

Figure 5: Supply Chain Management

Supply Chain Management

- **Partners and Cooperation:** Farmers collaborate closely with seed suppliers, feed agents, collectors, and exporters to ensure the seamless supply of inputs and the distribution of fish. This partnership is essential for maintaining an efficient operational flow and fostering coordination throughout the supply chain.
- **Transaction Agreements:** Formal agreements between stakeholders are established to define the price, quantity, and payment terms for seeds, feed, and fish. These agreements are critical for ensuring transparent and smooth financial transactions.
- **Cost and Operational Efficiency:** Optimizing costs in areas such as feed usage, transportation, and farming technologies is essential to maximize profitability while ensuring that product quality is not compromised.
- **Quality Management:** Continuous monitoring of water quality, feed, and operational standards is undertaken to ensure that the fish produced meet both local and international market standards.
- **Market Distribution:** Efficient delivery systems are employed to transport fish to local and international markets. Logistics are managed in a way that maintains the quality of the fish throughout the distribution process.

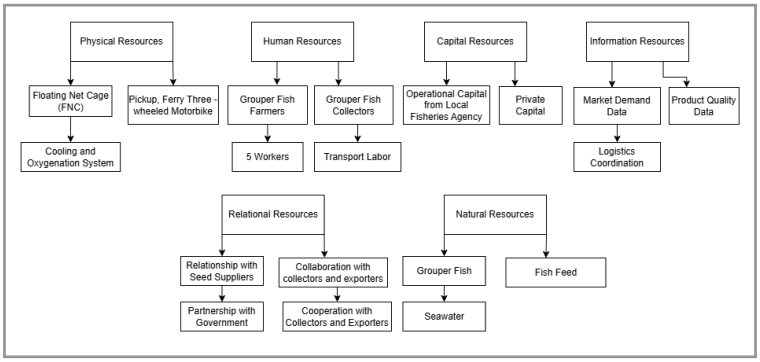

Figure 6: Supply Chain Resources

Supply Chain Resources

Physical Resources

Floating net cages (KJA) serve as the primary structure in Grouper Fish aquaculture. These cages, typically rectangular or cylindrical in shape, are supported by floats and frames made from wood, bamboo, or metal. Transportation resources, including ferry boats, three-wheeled motorcycles, and pickup trucks, are utilized to distribute both live and dead fish to market. Cold stor-

age facilities, or the use of ice, are essential for maintaining the quality of dead fish during transport. For fresh fish, refrigeration and oxygenation systems are employed to ensure the preservation of freshness, particularly during export shipments.

Human Resources

Fish farmers are responsible for raising Grouper Fish in KJAs, overseeing the process from the nursery phase to harvest. Collectors and distributors manage the collection, processing, and distribution of both live and dead fish to local and international markets. Transportation personnel, including boat operators and land vehicle drivers, also play a vital role in the logistics of fish distribution. Furthermore, aquaculture management experts from the Karimun Jawa National Park Center provide critical support in managing and validating fish farming data

Capital Resources

Operating capital is invested in the purchase of fish seeds, feed, and the maintenance of infrastructure such as KJA and refrigeration systems. Additional investments are directed toward water management technologies and oxygenation systems, which are crucial for ensuring fish quality, especially for export markets.

Information Resources

Market data plays a critical role in determining fish production volumes and sales, both in domestic and export markets, such as Japan. Additionally, product quality data is essential to ensure that both live and dead fish meet market standards. Effective logistics coordination is required to arrange delivery schedules, manage transportation conditions, and oversee cold chain management between collectors, distributors, and exporters. Data validation by independent experts is also crucial to ensure the accuracy of information related to the supply chain and production outcomes.

Natural Resources

Grouper Fish is the primary resource cultivated in the waters of Karimun Jawa, with the fish being raised from fry to consumption size. Good seawater quality is vital to support fish growth, necessitating regular monitoring. Specially formulated fish feed, sourced from an agent in Jepara, is another key resource that supports optimal growth of Grouper Fish.

Relational Resources

Strong relationships with seed suppliers in Situbondo are essential for the consistent supply of high-quality seed for aquaculture in Karimun Jawa. Cooperation with collectors and exporters, such as PT Nihon, is also crucial for distributing fresh fish to export markets, particularly Japan. Additionally, partnerships with the Central Java Marine and Fisheries Agency, as well as the Karimun Jawa National Park Agency, help ensure the sustainability and oversight of Grouper Fish production in the region.

Marketing Margin

The results of the marketing margin calculations are presented in the table below.

Table 2: Margin of Grouper Fish Marketing Channel in Karimunjawa, Central Jawa

No	Fish Condition	Actor	Selling Price (IDR per Kg)	Purchase price (IDR per Kg)	Margin	Marketing Cost (IDR per Kg)	Netto
1.	Fresh Fish	Fish Farmers	400.000	-	-	20.000	380.000
2.	Fresh Fish	Fresh Fish Trader	450.000	400.000	50.000	30.000	20.000
		Total (Fresh Fish)			**50.000**		
3.	Dead Fish	Fish Farmers	60.000	-	-	15.000	45.000
4.	Dead Fish	Dead Fish Trader (Domestic Market)	80.000	60.000	20.000	10.000	10.000
5.	Dead Fish	Dead Fish Retailer (Local Consumption)	100.000	80.000	20.000	10.000	10.000
		Total (Dead Fish)			**40.000**		

Fresh Fish Marketing Efficiency

$$\text{Efficiency} = \frac{Biaya\ Pemasaran}{Harga\ Konsumen\ Akhir} = \frac{50.000}{450.000} = 0.11\ \%$$

Marketing Efficiency of Dead Fish

$$\text{Efficiency} = \frac{Biaya\ Pemasaran}{Harga\ Konsumen\ Akhir} = \frac{35.000}{100.000} = 0.35\ \%$$

Farmer share

$$Farmer's\ share\ \text{Fresh Fish} = \frac{Pf}{Pr} = \frac{400.000}{450.000} = 88.9\ \%$$

$$Farmer's\ share\ \text{Dead Fish} = \frac{Pf}{Pr} = \frac{60.000}{100.000} = 60\ \%$$

Based on the marketing efficiency calculations 0.11% for fresh fish and 0.35% for dead fish along with an EP value below 1, the Grouper Fish marketing channel is deemed efficient. The farmer share of 88.9% for fresh fish and 60% for dead fish indicates that the marketing system delivers value to consumers at a low cost while ensuring a fair distribution. Therefore, the marketing efforts of farmers and intermediaries contribute to an efficient supply chain performance .

Conclusions and Further Research

Aquaculture supply chain management in Karimun Jawa, Jepara, Central Java, particularly for Grouper Fish, is structured

around five key elements. Like, fish seed suppliers, fish farming (encompassing hatchery, growth, and harvest processes), marketing channels (live and dead fish collectors), processing (domestic markets and fish processing companies), and consumers (restaurants, local markets, and exporters) and operates within a complex framework comprising four main models such as direct-to-sale, wholesalers, fish processors, and retailers with challenges and opportunities identified in areas such as water zoning regulations, Grouper Fish farming practices, resilience, export regulations, and by-product management, while performance evaluations using the FSCN (Food Supply Chain Networks) framework demonstrate that the marketing channels for both live and dead fish are functionin efficiently. Meanwhile, the future work could explore several areas to enhance the sustainability and economic potential of the Grouper Fish aquaculture industry in Karimun Jawa.

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